Studies in the Experimental Analysis of Sex.

By

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With Plate 14.

3. Further Observations on Parasitic Castration.

During my occupation of the British Association Table at Naples this winter I took the opportunity of re-examining certain points connected with the effect of Sacculina neglecta on the spider-crab Inachus mauretanicus, with the especial purpose of trying to settle the exact way in which the gonad of infected individuals degenerates and is absorbed. The mid-winter months being the most favourable season at Naples for finding numerous individuals of Inachus very profoundly modified by the presence of the parasite, I was able to re-investigate many crucial stages in the modification of the external and internal sexual organs, with the result that, while certain new facts of interest have come to light, I see no reason whatever for departing in any respect from the statement of facts made in my earlier work, or from the deductions drawn from them ('Naples Monograph,' No. 29, Chap. V). In this paper, besides giving the results arrived at in respect to the degeneration of the gonad, I propose to describe certain new instances of infected Inachus which afford incontestable proof that male crabs with differentiated though reduced male internal organs can assume all the adult female secondary sexual characters. It will also be shown both for the male and female sex that the effect of parasitic castration can on no account be interpreted as a return to a juvenile undifferentiated condition.

In Part 2 of these studies it has already been pointed out that this interpretation is ruled out by the facts, and this was also pointed out in my earlier work, but not in so detailed and categorical a form, with the unfortunate result that Professor T. H. Morgan, in a recent paper on "Sex Determination" ('Journal Exper. Zoology,' vol. vii, 1909, pp. 343, 344), has adopted this very explanation of my observations. Thus he writes: "The broad abdomen of the castrated male might be considered to correspond to the juvenile state. The only external structure cited by Smith that might seem to indicate that the characters of the castrated males are female rather that juvenile ones is the presence of hairs on the abdominal appendages of Inachus, absent in the young crab, but present in the adult female. Such evidence would not in itself be conclusive, since the presence of hairs may be due to increase in size or to a later moult rather than to latent female characters. Smith concludes that the male sex, and probably the male sex alone, can be so radically modified in its sexual nature as to assume a perfect external hermaphroditism. If, on the contrary, we assume that we have here, not hermaphroditism, but an imperfect development of male characters combined with the juvenile condition, we might offer a plausible explanation of the facts."

I am sorry that any want of explicitness on my part should have misled Professor Morgan, but I cannot accept the statement that the only characteristically adult female character, cited by me as being assumed by the infected males, is the presence of hairs on the abdominal appendages. I pointed out in my earlier work ('Naples Monograph,' xxix, pp. 67, 70 and 71) that in the young stages of the female, before the adult breeding form is assumed, the abdomen is a comparatively small flat plate, whereas in the adult it becomes suddenly widened and also takes on a hollowed trough-like shape, so that the two forms of abdomen are absolutely distinct morphological structures, distinguishable from one another at a glance (see figs. 1, 2, 3 and 4, Pl. VII, 'Naples Monograph' and again 'Quart. Journ. Micr. Sci.,' vol. 54, Pl. 30, figs. 10, 11, 13, 14). Now, when the infected males take on the female external characters they have never been found to assume the juvenile flattened form of abdomen which characterises the young stages of both males and females, but they invariably take on the hollow trough-like form characteristic of the adult breeding female and of her alone (see the numerous figures on the plates referred to above). That is the first objection to the view that the alteration of the male is merely towards a juvenile condition, and anyone who will examine the series of specimens exhibited in the South Kensington Museum or in the Oxford Museum, or those deposited by me at the Zoological Station at Naples, will at once perceive the entire morphological difference of the abdomen in the young and adult female, and the identity of the modified male abdomen with that of the adult female.

Secondly, with regard to the abdominal appendages. It is not a question of the mere presence or absence of a few hairs, as Professor Morgan has unfortunately been led to suppose. The abdominal appendages of the juvenile and adult individuals differ as radically, if not more radically from one another, than the form of the abdomen. In the young form of the female these appendages are short, stout and rod-like, and provided with a very few short bristles, as shown in Pl. 14, fig. 7 of this paper. In very young males similar appendages are present, but they are lost at a very early stage indeed, only the two anterior appendages being kept as the copulatory styles. The form of these two appendages in the young male is shown in Pl. 14, figs. 1 and 2.

The adult female, at the same moult at which it acquires the characteristic adult form of abdomen, assumes a totally different kind of appendage of the form shown in Pl. 14, fig. 4. Here it is seen that instead of being stout and rod-like with a few stiff hairs, as in the young females, the appendage has become transformed into two wisp-like branches, the exopodite being densely clothed with long plumose hairs, the endopodite, now a slender-jointed structure, being furnished with exceedingly long pointed hairs for the attachment of the eggs. The structure of these abdominal appendages in the adult female, adapted as they evidently are for reproductive purposes, is as morphologically distinct from that of the young individuals of either sex as anything very well could be.

Now let us inquire in what form the infected modified males assume the abdominal appendages. The answer is plainly given by reference to Pl. 14, fig. 4. This figure is an actual camera drawing of the second abdominal appendage of an infected individual, which was proved to be a male by the presence of a copulatory style of a somewhat modified form (Pl. 14, fig. 3), and internally by the presence of testes and vesiculæ seminales of a typical character on either side. The testis and vesicula seminalis of one side of this individual are shown in Pl. 14, fig. 10. The form of the abdominal appendages (Pl. 14, fig. 4), of which there were four on each side in addition to the copulatory styles, is identical with that of a normal adult female; in fact, since this figure serves equally well to depict the abdominal appendage of a normal adult female, I have not considered it necessary to give another figure, which would simply mean repeating the same structures.

The infected male individual to which figs. 3, 4, and 10 on Pl. 14 refer is a particularly favourable type for showing conclusively that the abdominal appendages, when assumed by the infected males, are of the characteristically adult female type. As a matter of fact a commoner condition is that shown in Pl. 14, fig. 5. In this infected male the copulatory style was greatly reduced (fig. 6) and the abdominal appendages were also developed in an imperfect condition, with almost complete suppression of the endopodites. Nevertheless, the characteristic plumose hairs are present on the exopodite, which is of a slender shape, thus conforming to the adult type of female appendage and not really approaching to the juvenile condition. This figure might equally well refer to the abdominal appendage of an infected female, in which the endopodites are very frequently thus reduced.

We have now examined in some detail two of the most important characters in which the infected male Inachus is modified by the presence of the parasite Sacculina, viz. the shape of the abdomen and the form of the abdominal appendages, and we have seen that Professor Morgan's attempt to explain the modification of the male as a return to a juvenile condition is quite at variance with the facts. But we have still two more points to consider, which render that explanation still more impossible.

The most important of these two points is the fact that in a certain small percentage of cases the infected males, on recovery from the parasitic disease, have been observed to have regenerated the gonad, and to have developed large ova measuring about 1 mm. in diameter and full of the reddish-coloured yolk characteristic of the mature ova of the female Inachus. Professor Morgan himself admits the cogency of this fact, so that I need not labour it here, its significance, indeed, being obvious.

The second point is one which I have only been able to settle finally during my recent visit to Naples. In my earlier work (loc. cit., p. 68) I inclined to the view that the presence of Sacculina caused the young females under 13 mm. in carapace length to assume prematurely the adult type of abdomen and abdominal appendage, and I emphasised this point as being of importance in precluding the view that the effect of the parasite was merely to arrest development or cause a return to a juvenile state. By a careful examination of the large amount of material put at my disposal by Dr. Lo Bianco this winter, I have found that this premature assumption of adult characters by infected females undoubtedly occurs. During December and January all the uninfected females of carapace length up to 14 mm. had the immature juvenile form of abdomen and appendage, but all the infected females measuring from 6–14 mm. had the fully adult type of both those structures. The real theoretical significance of this fact, which has an important bearing on the whole meaning of parasitic castration, will be discussed later, but it has been introduced here as a final nail in the coffin of the theory which attempts to explain the effects of parasitic castration as due to arrested development or the assumption of juvenile characters. Possibly the use of the term "parasitic castration" has had something to do with perpetuating this unfortunate error, the analogy between ordinary operative castration or mechanical removal of the gonads and their degeneration owing to the presence of a parasite being, as Professor Sedgwick has pointed out, extremely small. In parasitic "castration" the degeneration of the gonad is not brought about by the parasite mechanically removing or attacking the gonad, but by its setting up a deep-seated alteration of the metabolism of the host which secondarily reacts on the gonad. We may now enter into the question of the method of degeneration of the gonad. In the above paragraphs I trust that the following conclusion has been thoroughly vindicated. The modification of the male Inachus by the parasite Sacculina consists in the assumption by the male of adult female sexual characters to a greater or less degree of perfection; in neither sex can the modification be ascribed to arrest of development or the assumption of a juvenile immature condition.

As I have shown in my earlier work (loc. cit., pp. 72–74) the degenerate condition of the ovaries and testes with their ducts in infected Inachus is due to two causes: firstly, an arrest of growth, so that the gonad tends to remain in the same condition as it was when infection took hold, and secondly, to an actual absorption of the tissues of the gonad and their final disappearance, a process which was often accompanied by an actual irruption of the roots of the parasite into the germinal tissues. The arrest of growth of the gonad and the first stages of degeneration, at any rate in the male, were shown to be independent of the irruption of the Sacculina roots.

The method of absorption and disappearance of the gonad was not clearly made out, and it was my chief object this year to obtain some idea of how this process takes place, to observe, for example, whether phagocytosis takes any active part in it.

The condition of arrested growth without any signs of active degeneration is well exemplified by the testis and vesicula seminalis figured on Pl. 14, fig. 10, which was dissected out of the perfectly modified male whose appendages are represented in figs. 3 and 4. In Pl. 14, figs. 8 and 9, are drawn, on the same scale, the vesicula seminalis and a small portion of the coiled testis of an uninfected male of the same size, showing that the gonad of the infected individual has remained very small and undeveloped. Spermatozoa were entirely absent from the infected individual, whereas the vesicula of the normal individual was crowded with them. There is, however, another point to be observed. Investing the gonad of the normal individual is a thin sheath of connective tissue with flattened, darkly staining nuclei (*c.s.*, Pl. 14, fig. 9). In the infected individual this sheath is seen to be of proportionately greater thickness.

In Pl. 14, fig. 11, is shown a portion of the testis of an infected male in which the process of absorption of the gonad has proceeded to a considerable extent. In three places small disconnected masses of testicular cells (*t.*) are seen lying ensheathed by connective tissue; between the disconnected pieces of germinal tissue nothing remains but the connective-tissue sheath. By staining such preparations with a triacid stain, e. g. Ehrlich-Biondi, small globules are seen lying between the germinal nuclei and the sheath, which take up the orange stain. These globules may be looked upon as degeneration products of the germinal tissue in process of absorption. In none of the preparations which I have made of degenerating gonads is there any sign of phagocytosis, the degeneration appearing to take place by some process of auto-digestion.

Turning to the degeneration of the ovary, Pl. 14, figs. 12 and 13, we find exactly the same process. Fig. 12 represents a portion of degenerate ovary of an infected female, in which islets of ovarian tissue containing disintegrating ova are seen encapsuled in the connective-tissue sheath. Fig. 13 is a high power drawing of a small portion of the ovary showing the clear distinction between the germinal nuclei (*N*), the nuclei of the connective-tissue sheath (*cs*) and the degenerating ova.

In a very great number of infected crabs dissected no trace could be found of the remains of a gonad; and in these, allowing for a certain number in which I overlooked the degenerating remains, one must suppose that the process of encapsulation by connective tissue and auto-digestion had led to complete disappearance. I am unable to state for certain whether the connective-tissue sheath plays an active part in the absorption of the germinal tissue; the chief part is clearly due to a simple disintegration of the same nature as is now known to occur in the destruction and absorption of the larval organs of insects during metamorphosis. In this latter process it was formerly held that phagocytosis played the principal part, but it is now known that a process of auto-digestion by fluids is at least as active an agent.

To conclude this part, I will attempt to outline, in a more satisfactory manner than was possible before, an explanation of why it is that the presence of a parasite should bring about such profound physiological and morphological changes in its host.

We must clearly define, in the first place, what these changes essentially consist in. It has been shown in my earlier papers, and I trust still more fully brought out in this paper, that the effect of Sacculina on Inachus is to cause the infected individuals of both sexes to assume adult female characteristics. This results not only in transforming the males into hermaphrodites with preponderating female characters, but also in hastening on the assumption of adult female characters by immature females. The problem, therefore, resolves itself into this, Why should the presence of Sacculina cause the host of either sex to become adult female in nature ?

Let us examine what the process of becoming adult involves in an ordinary female crab. Plainly the most important change is the rapid elaboration of yolk material which accumulates in the ovary, causing the latter to grow to a very great size. This elaboration of food material in the ovary is the fundamental point in which the adolescence of the female gonad differs from that of the male. In the male gonad at maturity we have an immense multiplication of nuclei and of chromatin but a small development of cytoplasmic material and no deposit of yolk; in the female we have the exact opposite of this process. The most important part, then, in the process of becoming adult female, is the active elaboration of yolk material.

We have arrived, therefore, at this point of the argument: that the presence of Sacculina causes the crab of either sex to become adult female in nature, and the most important activity of this state is the elaboration of yolk material. Can we prove that the presence of Sacculina actually causes its host of either sex to produce yolk material? I believe we can. If the roots of Sacculina which fill the body of an infected Inachus be examined, they will be found to be packed with small globules of an oily material, and if the roots are stained with such a mixture as Ehrlich-Biondi's tri-acid stain it may be observed that the Sacculina roots take up the same constituent in the stain, namely the acid fuchsin, as the yolk of an adult female crab's ovaries. From the observed contents of the Sacculina roots and from their reaction to stains it is clear that they are elaborating from the blood of the Inachus of both sexes a closely similar yolk material to that which is normally accumulated in the ovary of a healthy adult female Inachus.

The effect of Sacculina on Inachus is therefore to force the latter to elaborate yolk material of a similar kind to that which is normally developed in the ovary of the female at maturity. As the Inachus elaborates it the Sacculina abstracts it, so that it does not come to be deposited in the gonad until after recovery from the disease, when, as we have seen, the yolk-containing ova may be formed in the gonad of either sex.

Meantime the continued production and circulation in the blood of the infected Inachus, whether male or female, of this yolk material, or rather of the substances from which the yolk is built up, is accompanied by the production of the secondary sexual characters proper to the adult female. These yolk-forming substances, or substance, are therefore identical with the "sexual formative substance," whose existence we deduced in Part 2 of these studies. We may summarise the above argument as follows: The Sacculina roots require for their nourishment a substance in the blood of the crab which they can work up into yolk material. This substance is provided for them in the female sexual formative substance, which is circulating in small quantities in normal male crabs as well as, in greater quantities, in female crabs. But the Sacculina roots must have the power, not only of abstracting this material from the crab's blood, but also of forcing the crab to go on forming this substance in excess. This may seem to be a great assumption; but it is exactly here that a very close parallel can be drawn between the phenomenon we are dealing with and the general processes of immunity to parasites and organic poisons. Immunity has been interpreted, especially by Ehrlich, to mean that when a poison acts upon an organism it combines with and anchors certain organic molecules, which are then regenerated in excess and poured out into the blood-stream as antibody. If we suppose, therefore, that the Sacculina roots anchor the molecules of the female sexual formative substance, and this, from the fact of their forming yolk material, they appear to do, it is in accordance with the facts of immunity to suppose that the molecules of the sexual formative substance, wherever they are formed, will be regenerated in excess.

The continued operation of this process, namely, the production of female sexual formative substance in the blood-stream, and its abstraction by the Sacculina roots, would account for all the observed phenomena, viz. the development of adult female characters, which are dependent on the presence of this substance in quantity in the blood, and the abortion of the gonad owing to the Sacculina roots seizing on its proper nutriment and not permitting it to grow or develop. Nevertheless in the case of the hermit-crab infected by Peltogaster, Potts has shown that small eggs may be formed in the gonad, even while the parasite is still vigorous, showing that the excess of sexual formative substance has to some extent been seized on by the gonad.

In the above manner it appears to me that we not only gain a clear idea of the process involved in "parasitic castration," but the phenomenon, instead of appearing an isolated curiosity of a wholly inexplicable nature, falls into line with the well-known reactions to parasitic infections which are classed under the category of immunity. The clue to the whole theory rests in the truth of the statement that "parasitic castration" consists in the assumption by the infected individuals of adult female characteristics, owing to the development within them of the female sexual formative substance. If this statement of the case is rejected by the reader on the evidence which I have adduced, he will naturally reject the theory proposed to account for it, and if he can succeed in framing a different and more satisfactory theory which will include all the facts I shall be very well pleased.

But any attempt to explain "parasitic castration" by vague analogies with the effects of operative castration, or by referring the whole phenomenon to arrested development or appearance of juvenile characters, is certainly foreordained to failure.

The explanation here offered of parasitic castration differs from that which I proposed in my first work ('Naples Monograph,' xxix, p. 82, et seq.) only in its greater precision, not in its general outline. In my original statement of the theory I ascribed the alteration of the male to an adaptive response of the metabolism in order to make good the drain on the system caused by the presence of a parasite. The metabolism was represented as changing from the katabolic male condition to the more anabolic female, and this change was supposed to be effected by the development in the body of the female sexual formative substance. It is clear that this theory is fundamentally the same as that now proposed, but being couched in rather vague and general language, it seems to have made very little impression even on those who unreservedly accepted my statement of facts. By showing, firstly, that the assumption of the adult female condition involves an active elaboration of yolk material, and secondly, that the Sacculina roots actually withdraw some substance from the crab's blood from which they manufacture a yolk substance closely similar to that normally deposited in the eggs of the crab, and also by emphasising the fact that in reality both sexes of the host react in exactly the same way to the parasite, it has been possible to express the theory in a far more objective manner.

Summary of Part 3.

(1) The effect of Sacculina on male Inachus consists in the assumption by the male of adult female characteristics, and can in nowise be ascribed to arrest of development or acquisition of juvenile or immature characters, as suggested by Professor T. H. Morgan.

(2) The effect of Sacculina on young immature females of Inachus is to force them to assume prematurely adult female characteristics.

(3) The absorption of the gonad of infected Inachus of both sexes is brought about by a process of ensheathment with connective tissue and auto-digestion, phagocytosis apparently playing no part.

(4) The reason why Sacculina causes the assumption of the adult female state in Inachus is found in the facts (1) that the roots of Sacculina elaborate a yolk-substance from the blood of Inachus of a similar nature to that which is elaborated in the ovaries of an adult female Inachus; (2) that in order to elaborate this yolk substance they take up from the

blood of *Inachus* the female sexual formative substance, which is the necessary material for forming the yolk; (3) that the female sexual formative substance, being anchored by the *Sacculina* roots, is regenerated in excess; (4) that the presence of the female sexual formative substance continually circulating in large quantities in the body-fluids of the infected crabs causes the production of adult female secondary sexual characters, and, when the parasite dies, of yolk-containing eggs.

4. On a Case of Parasitic Castration in a Vertebrate.

Although numerous cases are now known of the presence of a parasite causing arrest of development or degeneration of the reproductive organs in various invertebrates, no clear instance of this process has been reported, so far as I am aware, among vertebrate animals as the result of bacterial disease of organs other than the reproductive organs themselves. Of course, where the reproductive organs themselves are the seat of infection, a certain amount of atrophy or degeneration may naturally result, but we have here to deal with a case of parasitic castration, analogous to the case of *Sacculina* on *Inachus*, or of *Entoniscus* on various crabs, where the reproductive organs are not themselves necessarily attacked by the parasite, but are secondarily affected by the general disturbance of the metabolism, set up by the presence of a parasite in other parts of the body.

During December, 1909, I received a pure-bred *Gallus bankiva* cockerel for breeding purposes. It belonged to the breed known as the Indian Jungle Fowl, a breed which has departed very little from the wild *Gallus bankiva*. The bird when it arrived appeared in good health; the plumage was in good condition, the comb and wattles well developed and red, the spurs fully developed, the tail carried erect, and the bird crowed in the normal manner. Its age was one year and a half. About two weeks after it arrived it showed signs of sickness and a tendency to mope in the straw at the back of its run. These symptoms became gradually worse, and at the beginning of February the whole appearance of the bird was changed: the comb and wattles were greatly shrunken, and instead of being bright red were unhealthy pink patched with grey; the skin round the eyes was bloodless; the tail was carried drooping, and the bird never crowed. The bird was isolated and treated with purgatives, but the illness continued, the comb and wattles having withered by the middle of April to about half their original size. The spurs and plumage were unchanged, save for the fact that the tail was always drooped. The bird was killed and dissected on April 8th.

The post-mortem examination showed that it was suffering from very acute avian tuberculosis. The liver was interpenetrated with whitish calcareous nodules swarming with the characteristic tubercle bacillus, while the whole course of the alimentary canal, pancreas and spleen was covered with similar swellings, some of them of the size of a pea, also full of living bacteria. Only the alimentary and lymphatic organs were infected, the lungs, kidneys, and testes being entirely free of infection.

Although the testes were uninfected, it was at once apparent that they were very remarkably reduced in size, measuring only 10 mm. in length by 5 mm. in breadth, whereas in a normal cockerel of the same breed and age, at the same time of year, they measured 40 mm. in length by 25 mm. in breadth. The vasa deferentia were also reduced in size, and this was especially noticeable in the coiled lower part of the tubes where they pass into the vesiculæ seminales; no spermatozoa were present.

Sections of the testes showed the testicular tubes intact, with a regular lining of germinal epithelium cells with nuclei in a resting condition. There was no sign of any mitosis or of any other stages in the process of spermogenesis. The testicular tubes, in fact, presented the appearance characteristic of immature birds of a few weeks old.

In a certain number of the tubes degenerating germinal cells with abnormal nuclei could be seen.

In contrast to this extreme reduction and arrest of development in the germinal part of the glands, the interstitial cells, forming islets everywhere between the testicular tubes, were well marked.

There was no trace of infection by the tubercle bacilli in either testis.

It is clear from the course of the disease and from the post-mortem examination that the reduction of the comb and wattles and the atrophy of the testes went hand in hand with the acute development of the tuberculosis. We know from numerous experiments that the effect of the removal of the testes in Gallus is to arrest the development of the comb and wattles; otherwise, except for the loss of the crowing and the drooping of the tail, the other secondary sexual characters are not affected. We have seen that as the bird in question became ill, the principal symptom was the reduction in the comb and wattles, and the post-mortem showed that the testis must have been accompanying these organs in a process of atrophy.

We have, therefore, in this case, an instance of parasitic castration caused by a bacterial infection of a vertebrate host, exactly parallel to the cases of parasitic castration in various Invertebrata caused by such various parasites as Crustacea, Sporozoa, and worms of various kinds. In a great number of these cases the effect of the parasitic castration is to arrest the development or cause the atrophy of the primary and secondary sexual characters without actively calling forth the production of the female sexual characters in the parasitised male. In other cases (as far as we know only in the Crustacea) besides the suppression of the sexual characters both primary and secondary proper to the infected individual, we find the active assumption of female characters by the parasitised male, as described in Parts 2 and 3 of these studies. The particular case just described belongs, as far as the evidence goes, to the former of these two categories, *i. e.* that in which certain of the male sexual characters atrophy without the active assumption of female characters. The principal interest attaching to this case consists, firstly, in establishing a bacterial disease of a vertebrate as a cause of parasitic castration and thus extending the operation of this principle to two new classes of organisms, and secondly, in bringing out the correlation between the activity of the testes and the development of the comb and wattles of Gallus bankiva. In the next part this correlation will be dealt with more fully on an experimental basis.

Lettering.

C. S. Connective tissue sheath. *En.* Endopodite. *Ex.* Exopodite. *N.* Germinal nuclei. *O.* Ovary. *T.* Testis. *V. S.* Vesicula seminalis.

EXPLANATION OF PLATE 14,

Illustrating Mr. Geoffrey Smith's paper on "Studies in the Experimental Analysis of Sex."

All the figures refer to Inachus mauretanicus (Lucas).

Fig. 1.—First abdominal appendage (copulatory style) of normal uninfected male. × 5.

Fig. 2.—Second abdominal appendage of normal uninfected male. × 5.

Fig. 3.—First abdominal appendage of infected male "A." × 5.

Fig. 4.—Second abdominal appendage of infected male "A." × 5. (This figure might serve equally well for the abdominal appendage of an adult female.)

Fig. 5.—Second abdominal appendage of infected male "B." × 5.

Fig. 6.—First abdominal appendage of infected male "B." × 5.

Fig. 7.—Second abdominal appendage of normal uninfected female, before adult condition is assumed. × 5. (The adult form of this appendage is practically identical with that given in fig. 4.)

Fig. 8.—Vesicula seminalis of a small normal male, measuring 14 mm. carapace length. × 20.

Fig. 9.—Coils of testis of the same male. × 20.

Fig. 10.—Vesicula seminalis, duct, and coils of testis of infected male "A." × 20.

Fig. 11.—Portion of testis of an infected male, showing absorption of germinal cells in connective-tissue sheath. × 30.

Fig. 12.—Portion of ovary of an infected female, showing absorption of ova and germinal cells in connective-tissue sheath. × 30.

Fig. 13.—Another portion, higher magnification, of ovary of infected female. × 60.